2018 PMM Science Team Meeting, October 8-12, 2018, Phoenix, AZ

Current status of GPM Ground Validation over Korea

October 11, 2018

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NMSC/KMA

NMSC

Outline

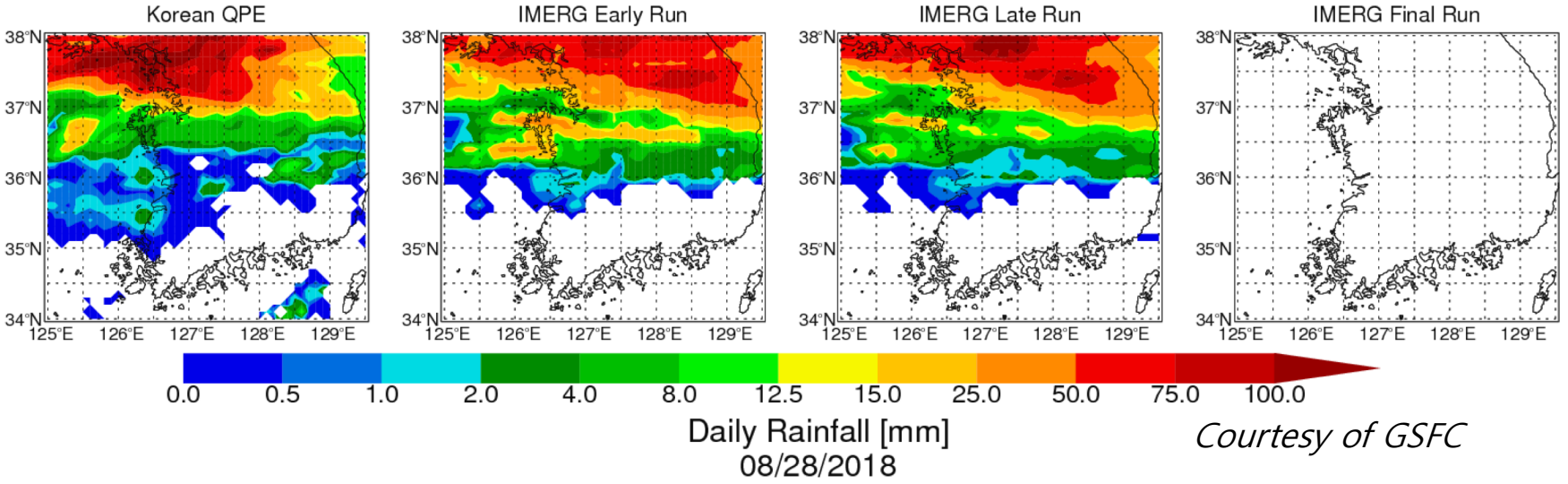
1 **Overview GV activity in Korea**

2 **Direct Validation**
Summer 2018 result

Overview GPM Ground Validation Activity in Korea

PMM history in Korea

- KMA/NASA GPM/PMM joint research (no-cost proposal)
  - Approved August 2009
  - Collaborating efforts to contribute GPM ground validation
    - Providing Real-time adjusted Radar-AWS rainrate (RAR) data for 11 KMA radar sites
    - Korean QPE data 1 x 1 km, 1-hour resolution
    - Comparisons between IMERG(V05) and Korean QPE (125~129.5E, 34-38N) since Mar 2014 (https://gpm-gv.gsfc.nasa.gov)
  - Publishing the GPM ground validation report using KMA observation network
    - Twice a year: Whole year and Summer (Snowfall report using GPROF)



Courtesy of GSFC

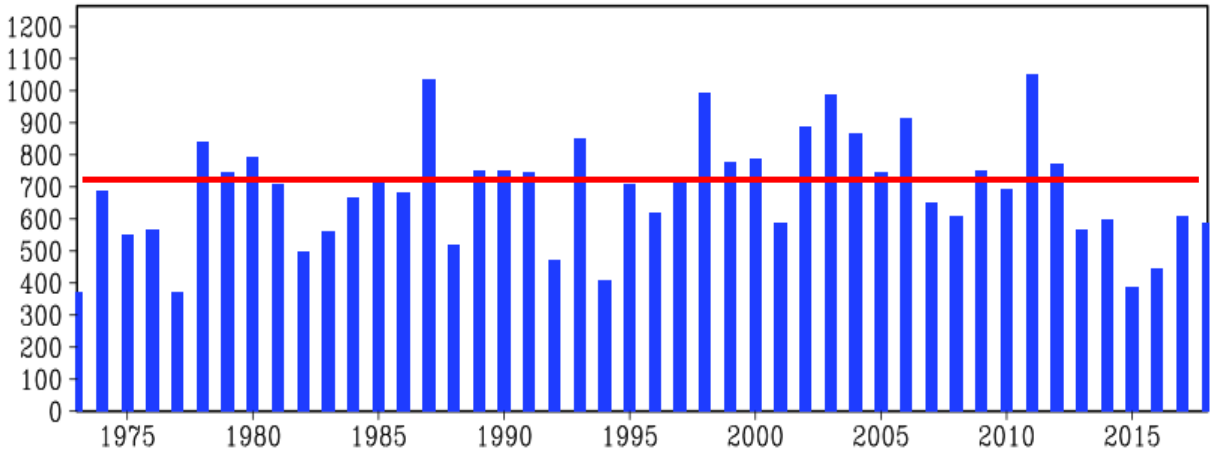
Climatology

During the Summer in Korea

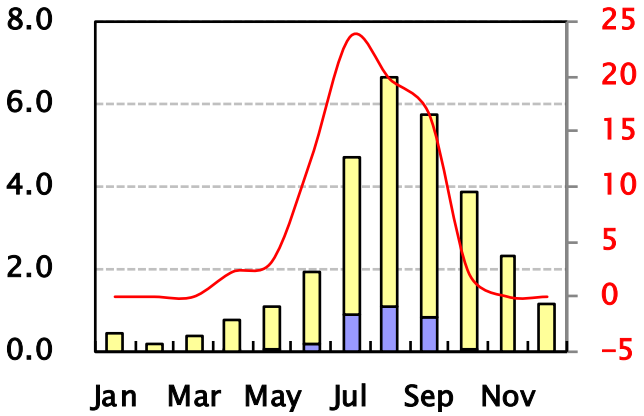
- Monthly mean rainfall is 720mm (125mm in June, 290mm in July, 275mm in August) over recent 30 years (1981-2010)
  - Rainy season during the Summer for around 30 days

- Typically Typhoon active this season including October
  - mean occurrence is 11 (direct impact 2)

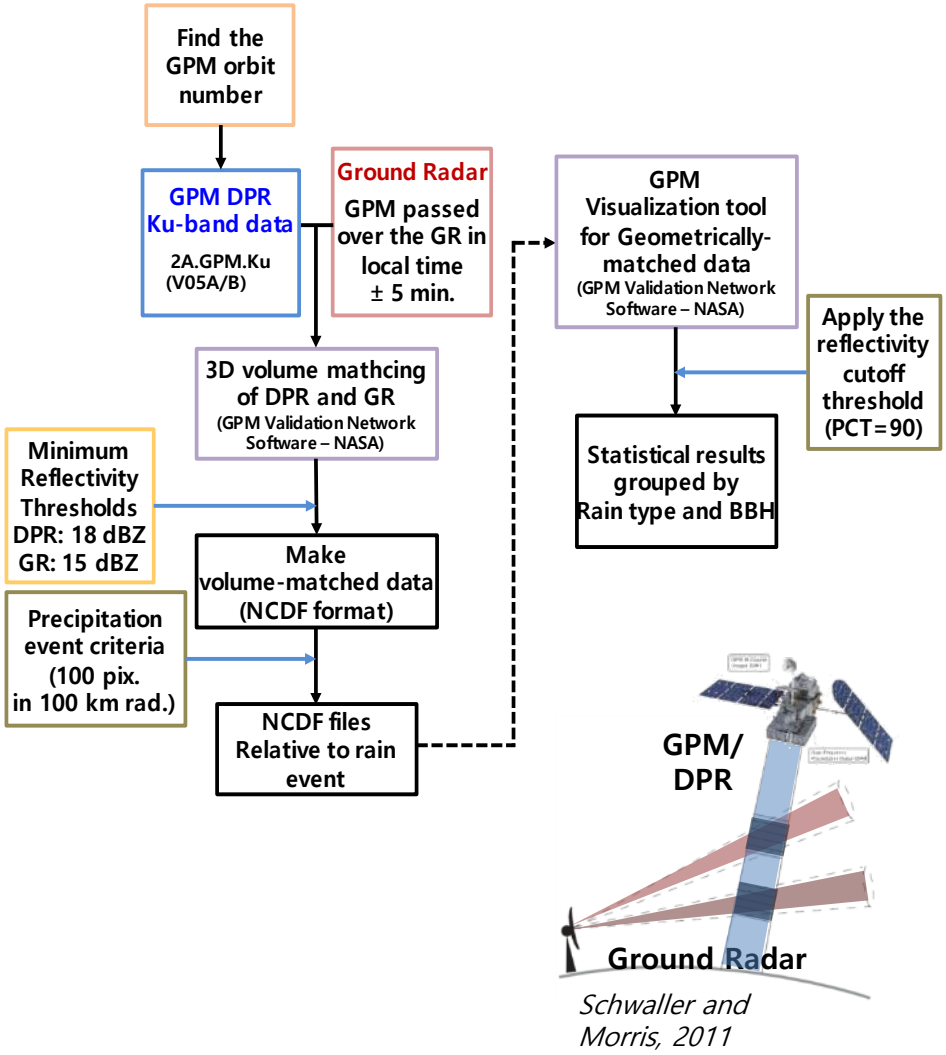
<Yearly mean rainfall during JJA, 1973~2018>



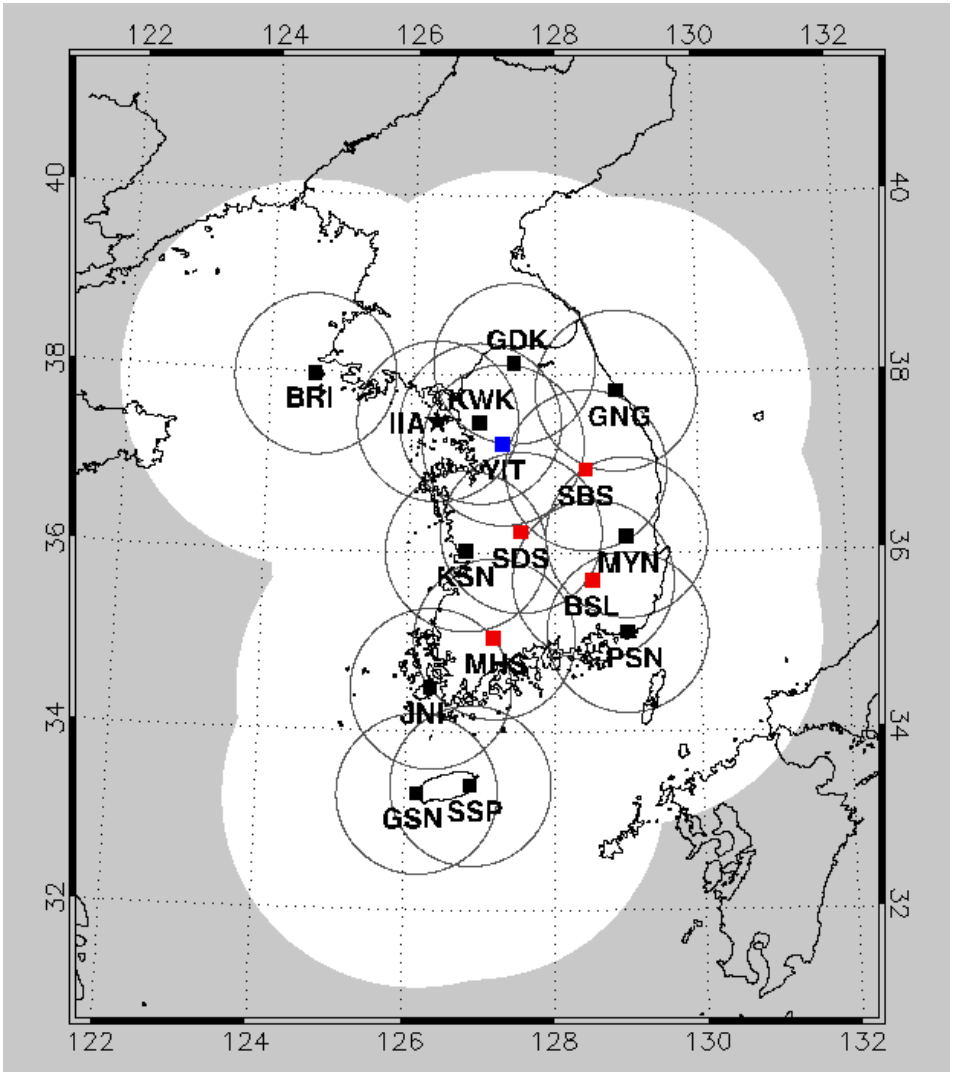
<Typhoon occurrence rate by month>



Ground validation over Korea



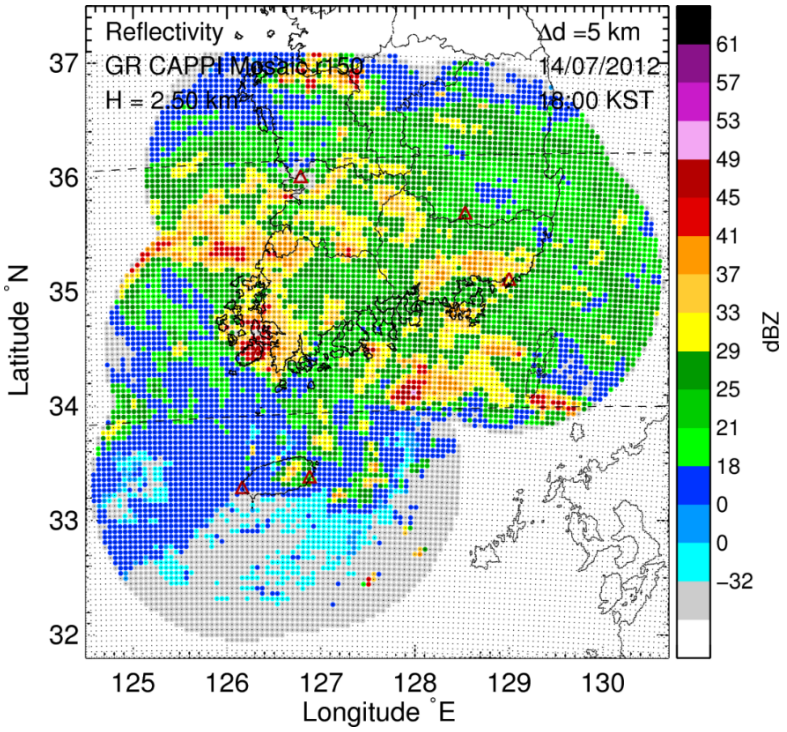
Schwaller and Morris, 2011



Black : KMA ground radar
Blue : KMA test-bed
Red : MoLIT ground radar

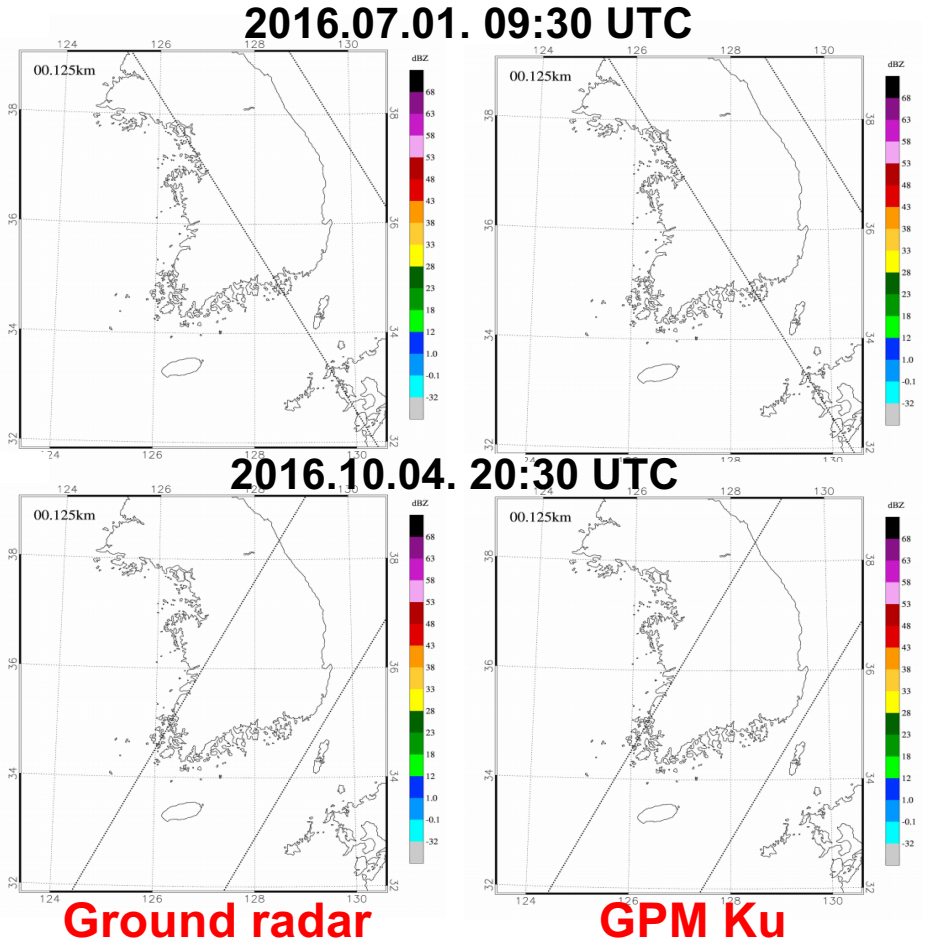
Digital Forecast System (DFS)

- ✓ Provide village scale forecasts every 3-hr up to 3 days since 2008
- ✓ Horizontal resolution can be changed from 5 km to 35 km.



[GR reflectivity over DFS coordinates]

- ▪ **GPM DPR (KuPR, KaPR)**
- ✓ Level 2 Version 05A/B
- ✓ Spatial distribution : 5 km
- ✓ Near surface rain rate



Summer 2018 GPM ground validation over Korea

Summer 2018

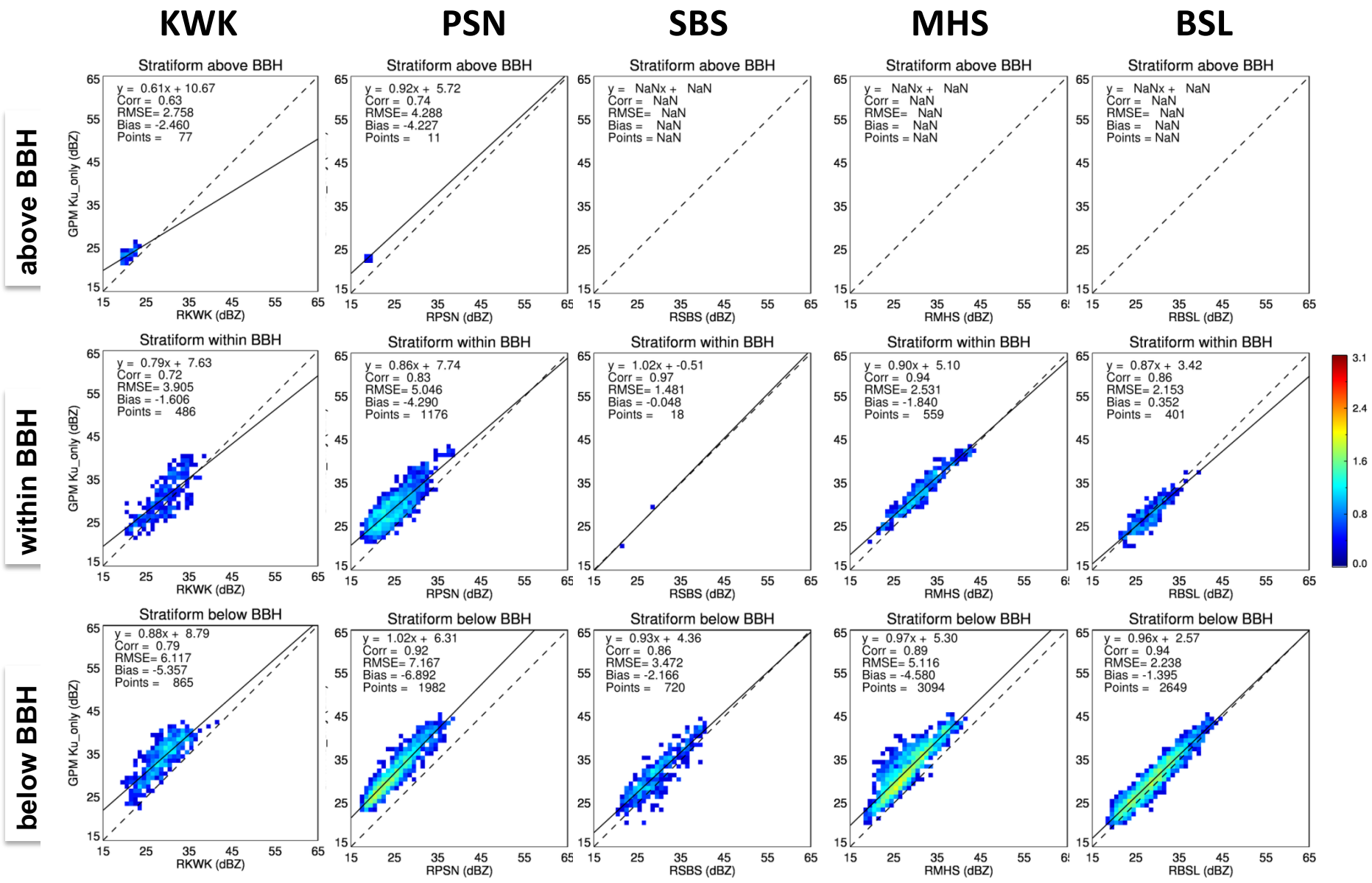
- Monthly mean rainfall is 720mm (125mm in June, 290mm in July, 275mm in August) over recent 30 years (1981-2010)
  - In 2018, total 587mm (106mm in June, 172mm in July, 282mm in August)

- Typhoon activity
  - mean occurrence is 11 (direct impact 2)
  - 3 out of 18 typhoon occurred are impact to Korea this year

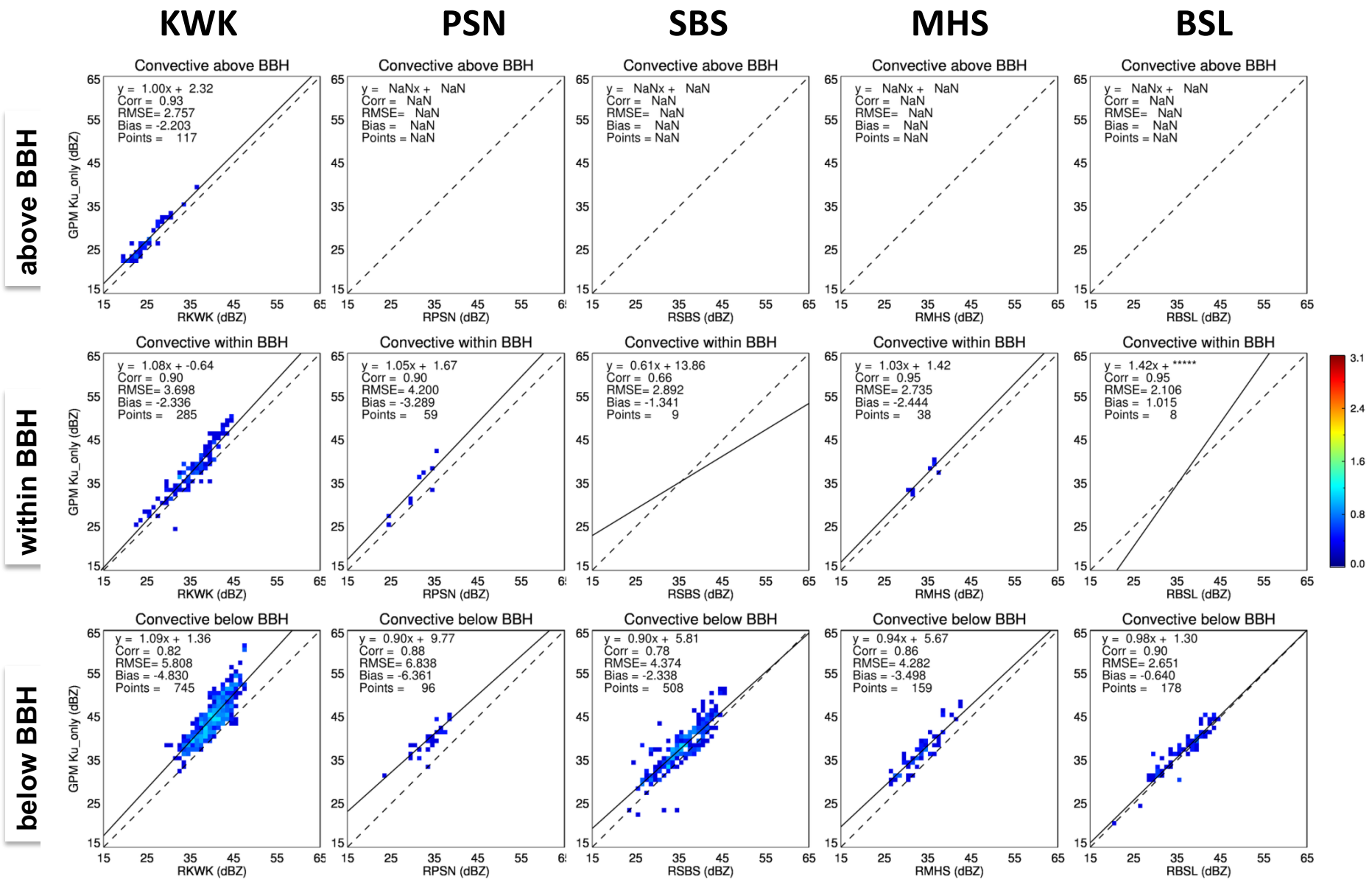
Number of collocated case for each GR site

Site	RJNI	RPSN	RKWK	RMYN	RGNG	RBRI	RYIT	RBSL	RSBS	RMHS	RSDS
Event	3	3	5	3	2	4	2	4	4	5	5

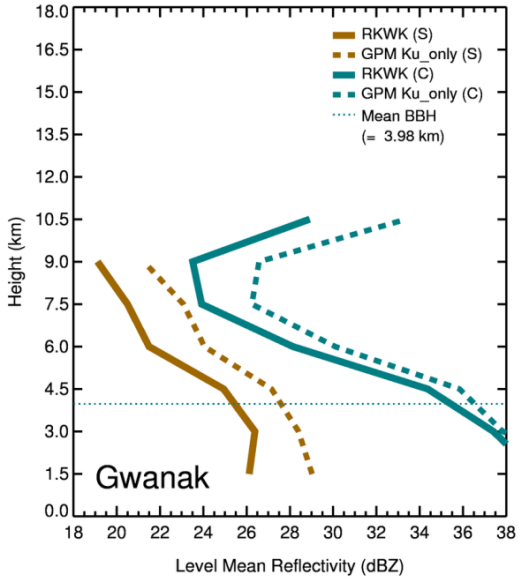
Reflectivity (Stratiform)

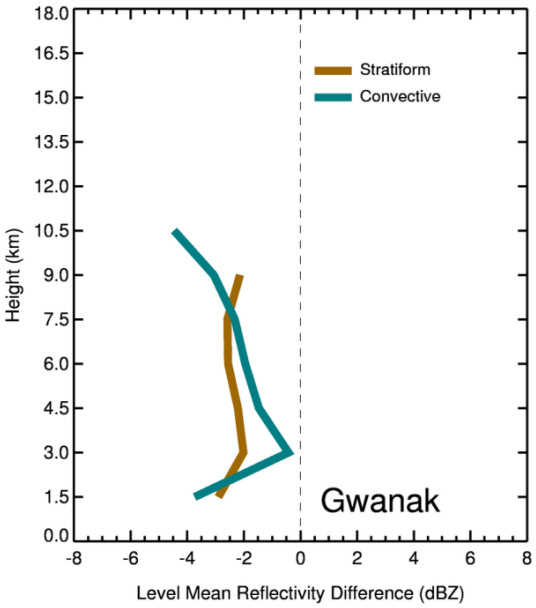


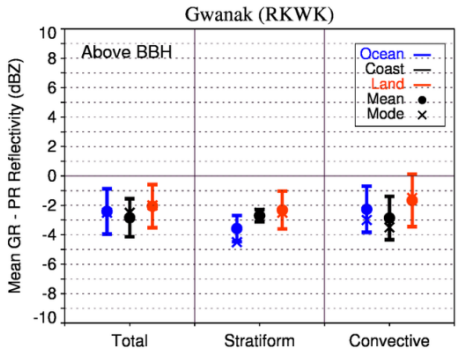
Reflectivity (Convective)

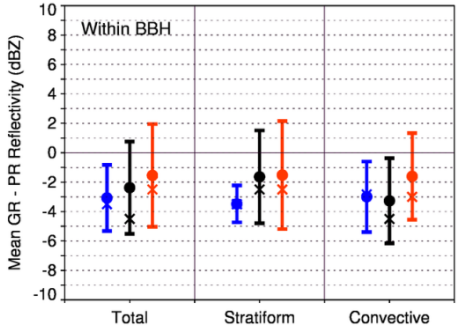


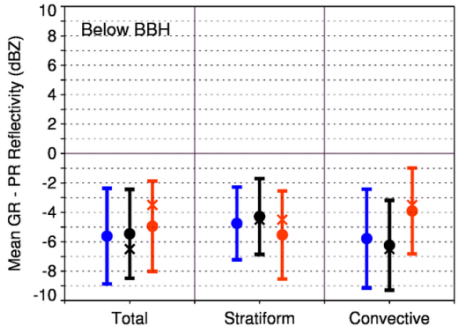
RKWK site

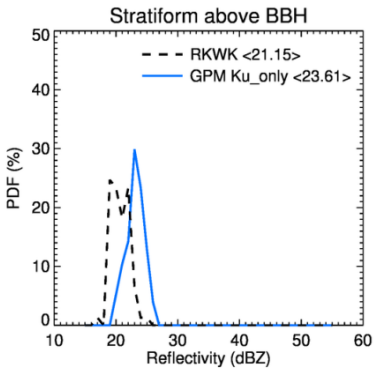

RKWK (S)
GPM Ku_only (S)
RKWK (C)
GPM Ku_only (C)
Mean BBH
(= 3.98 km)
Gwanak
Height (km)
Level Mean Reflectivity (dBZ)

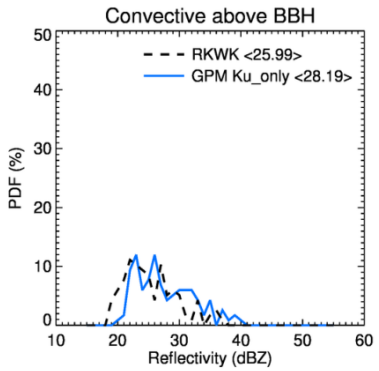

Stratiform
Convective
Gwanak
Height (km)
Level Mean Reflectivity Difference (dBZ)

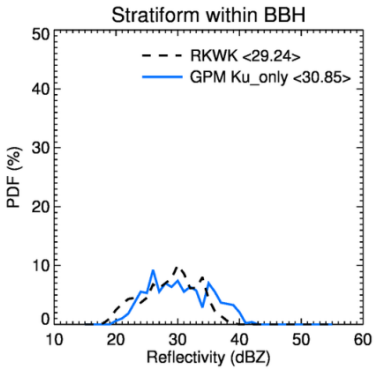

Gwanak (RKWK)
Above BBH
Ocean
Coast
Land
Mean
Mode
Mean GR - PR Reflectivity (dBZ)
Total
Stratiform
Convective

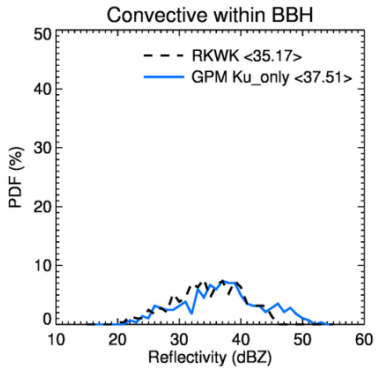

Within BBH
Mean GR - PR Reflectivity (dBZ)
Total
Stratiform
Convective

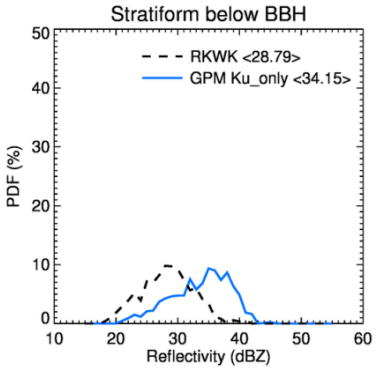

Below BBH
Mean GR - PR Reflectivity (dBZ)
Total
Stratiform
Convective

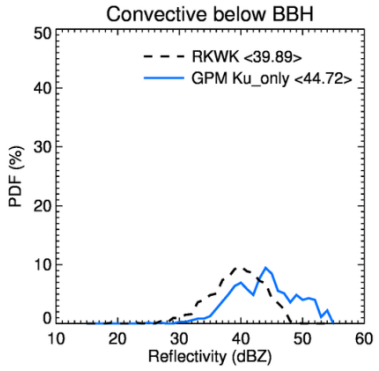

Stratiform above BBH
RKWK <21.15>
GPM Ku_only <23.61>
PDF (%)
Reflectivity (dBZ)


Convective above BBH
RKWK <25.99>
GPM Ku_only <28.19>
PDF (%)
Reflectivity (dBZ)

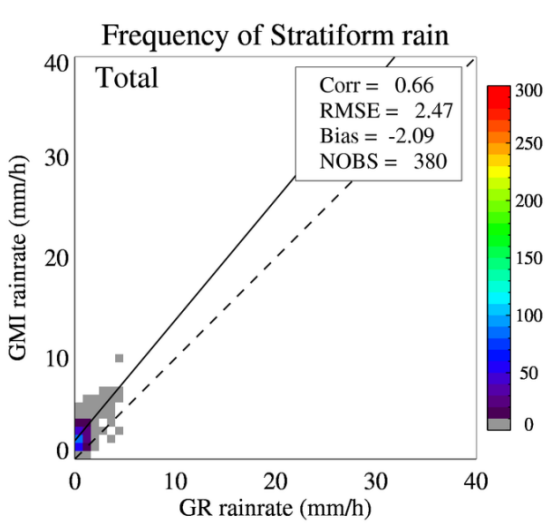
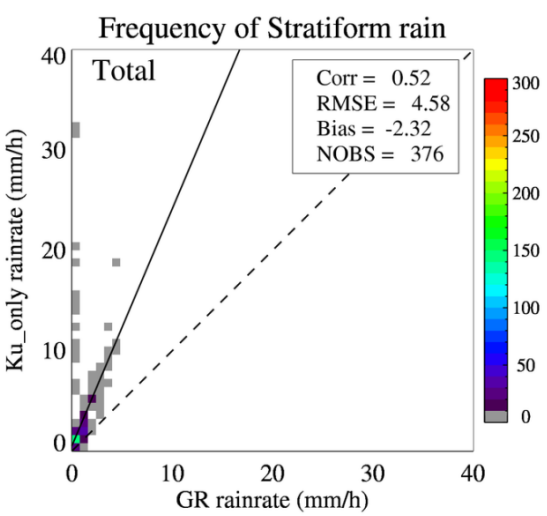
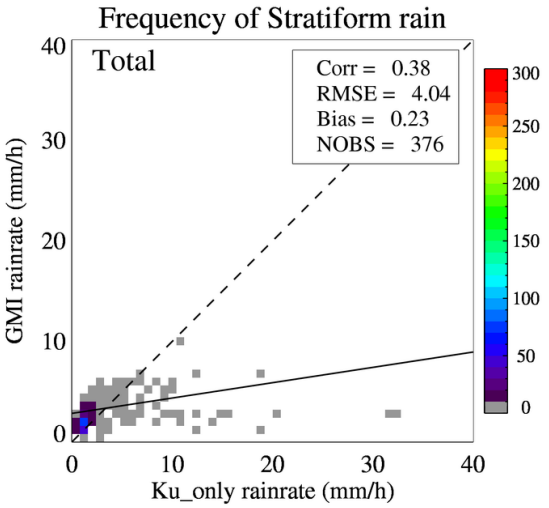
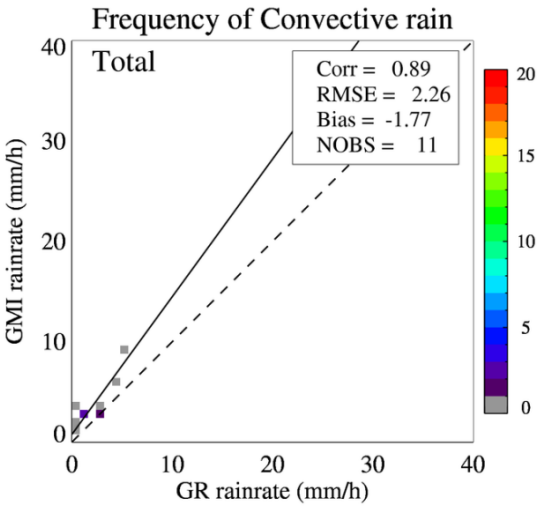
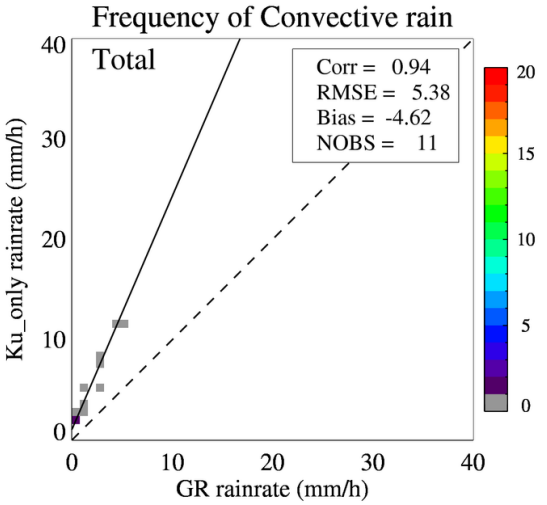
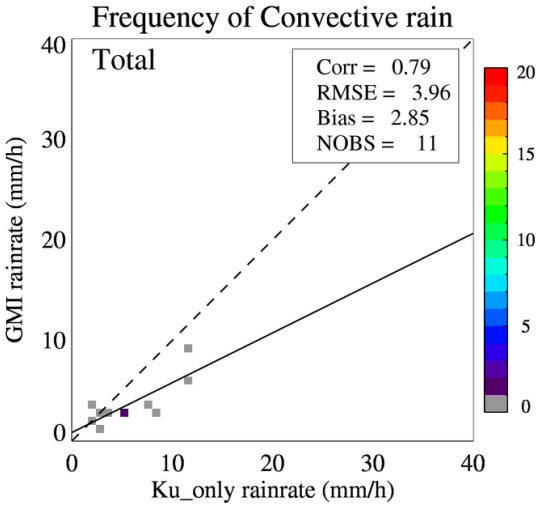

Stratiform within BBH
RKWK <29.24>
GPM Ku_only <30.85>
PDF (%)
Reflectivity (dBZ)


Convective within BBH
RKWK <35.17>
GPM Ku_only <37.51>
PDF (%)
Reflectivity (dBZ)


Stratiform below BBH
RKWK <28.79>
GPM Ku_only <34.15>
PDF (%)
Reflectivity (dBZ)

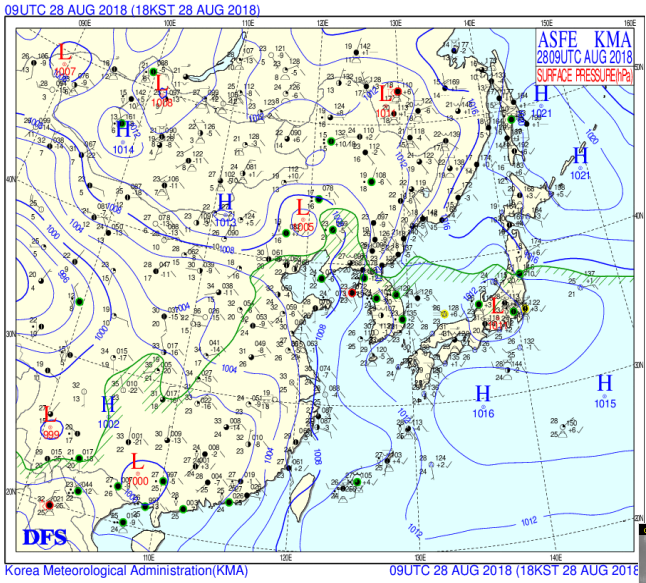

Convective below BBH
RKWK <39.89>
GPM Ku_only <44.72>
PDF (%)
Reflectivity (dBZ)

Ground Radar vs GPM Rain rate

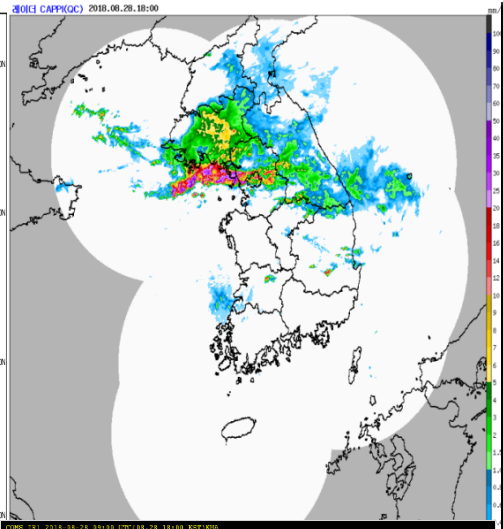
	GR vs. GMI	GR vs. KuPR	KuPR vs. GMI
Stratiform			
Convective			

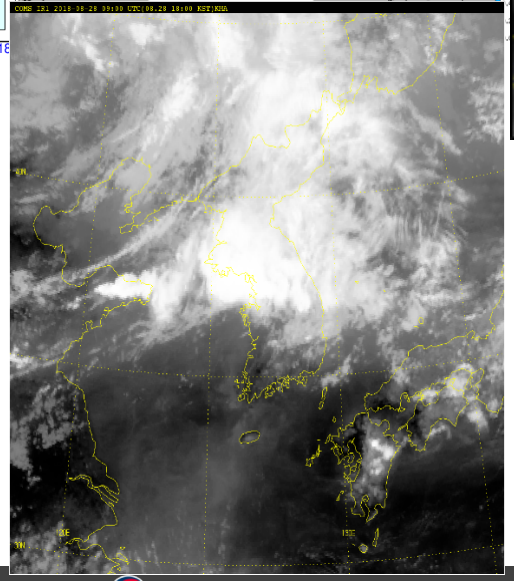
Case study (August 28, 2018 10Z)

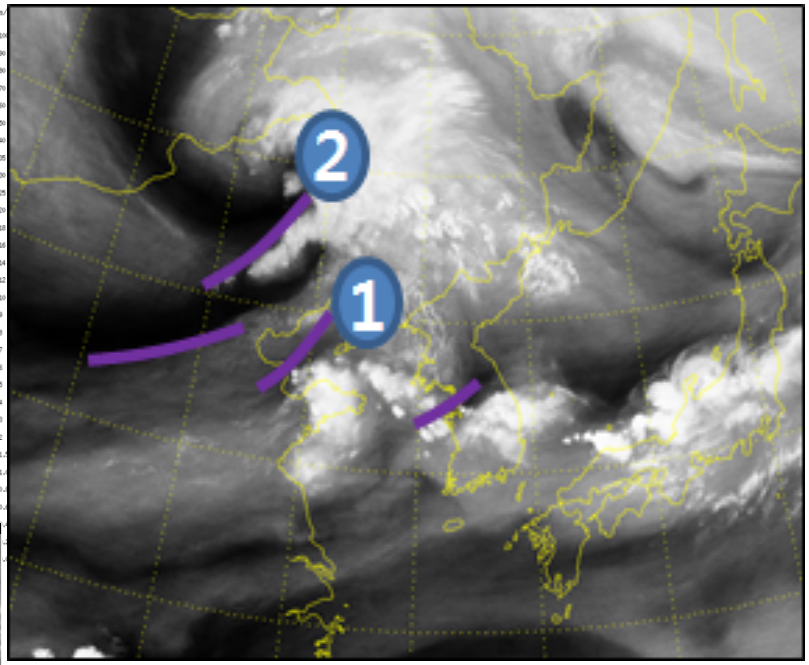
Weather Chart 08/28/18 09Z



Radar and COMS IR



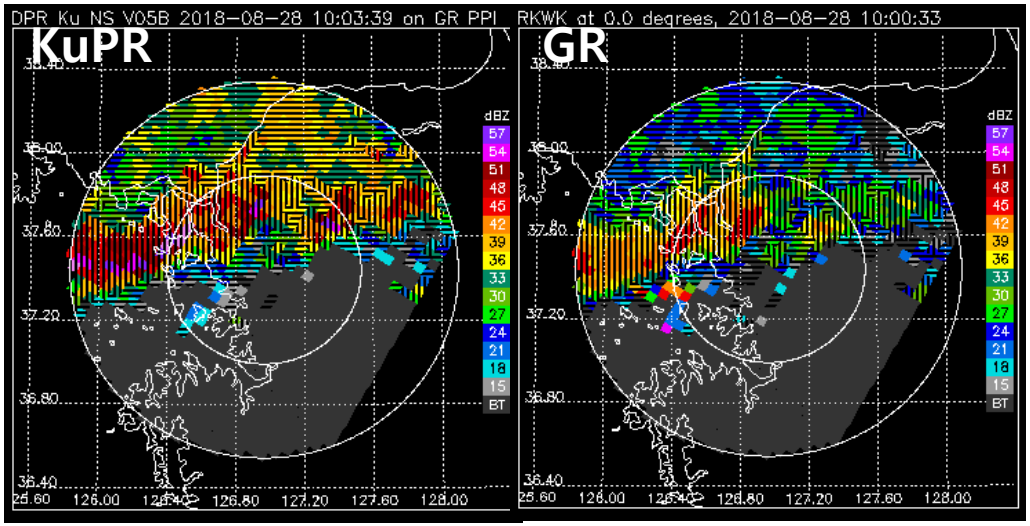


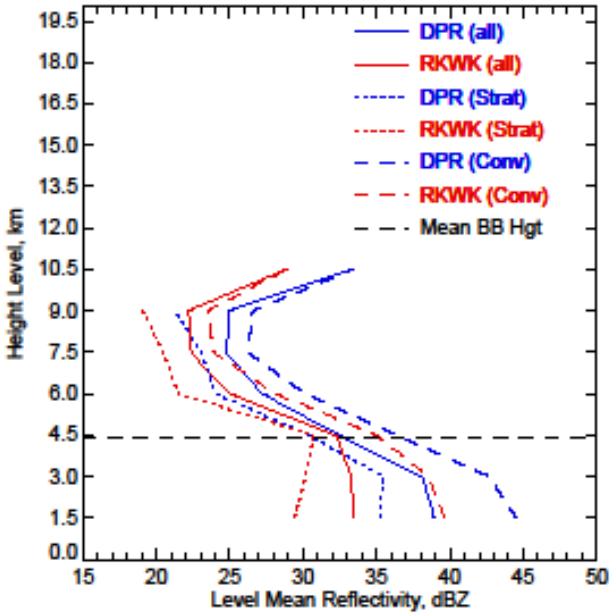


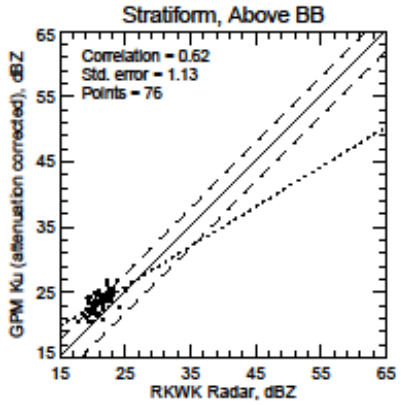
Forecast rain in Seoul area (50~150mm) and shower in Southern part of S.Korea (200mm~)

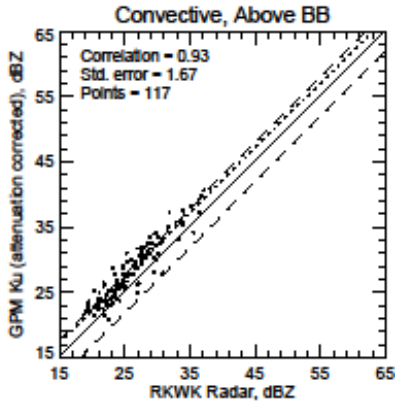
① rain influence by trough
② stay cold front due to the high pressure on South

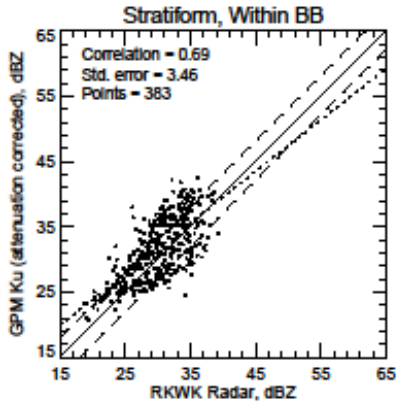
Direct comparisons (RKWK)

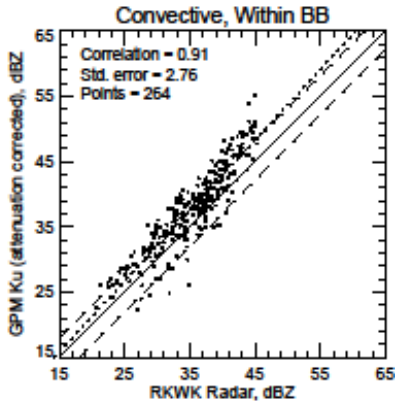


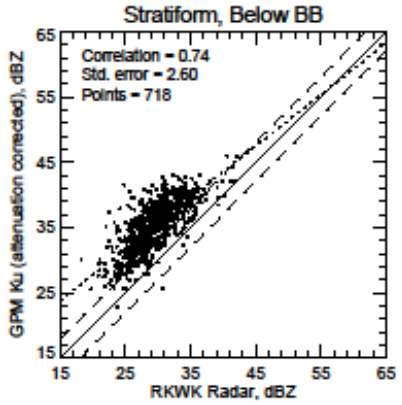


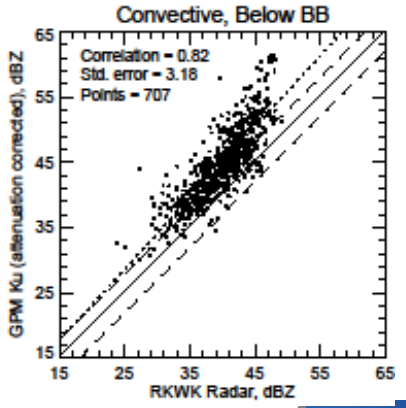






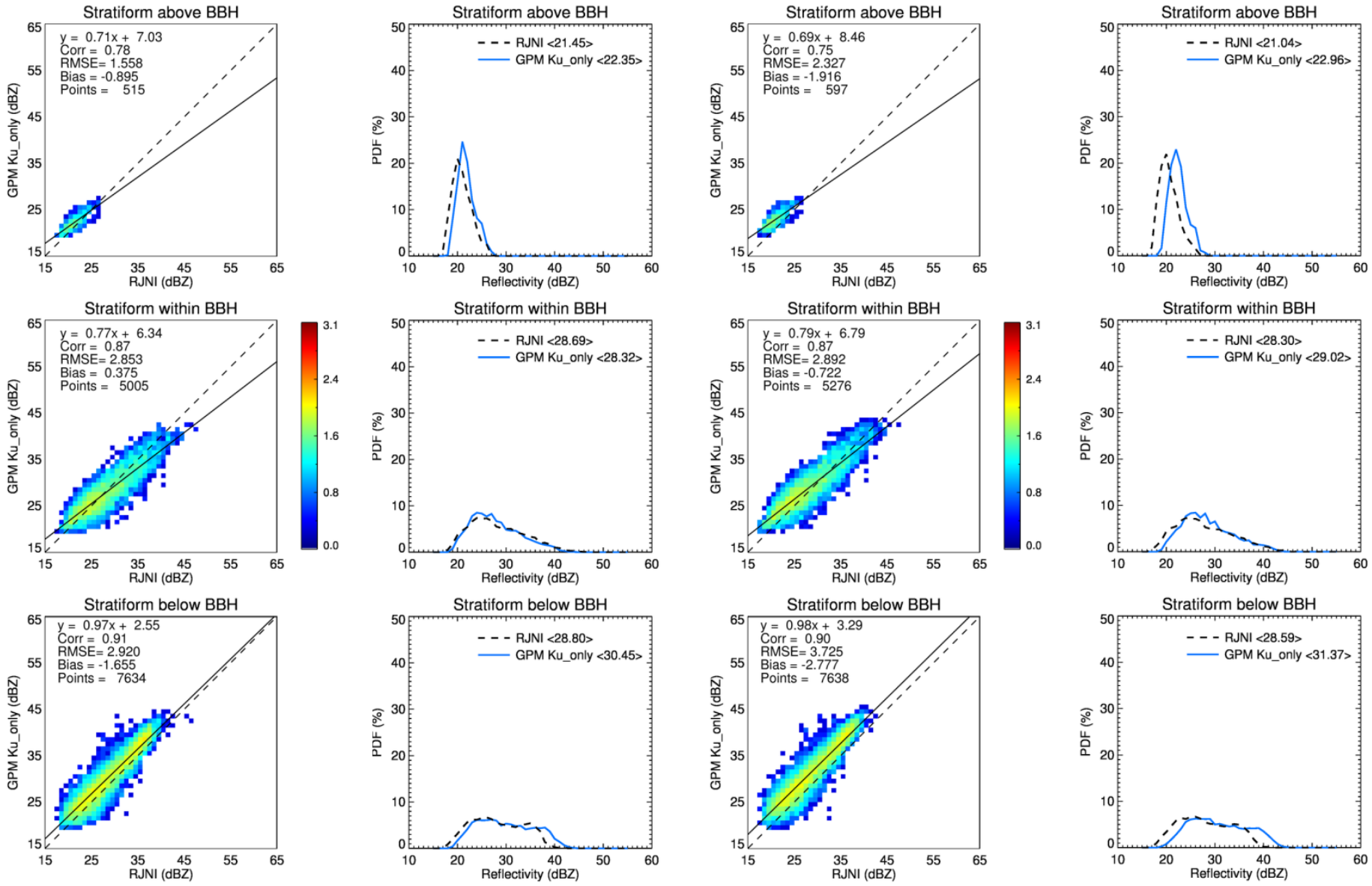






Version differences

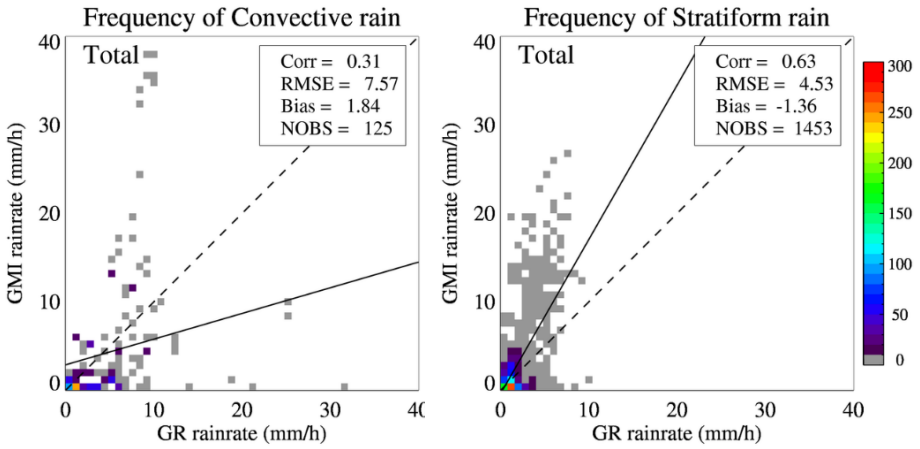
V4 **Period: Mar. 2016 ~ Feb. 2017** **V5**



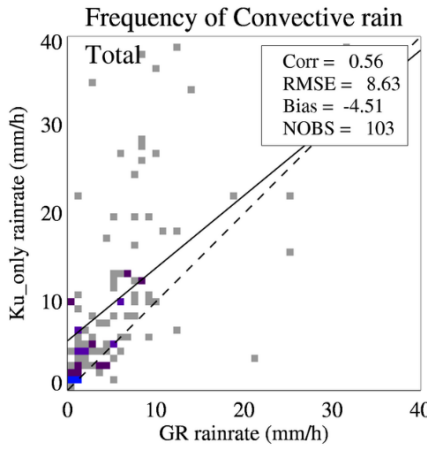
Version differences – cont.

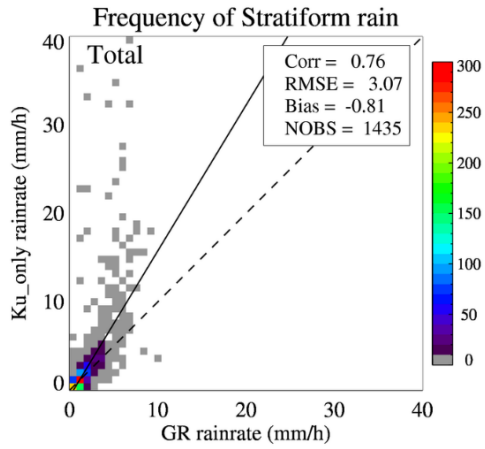
V4

GMI

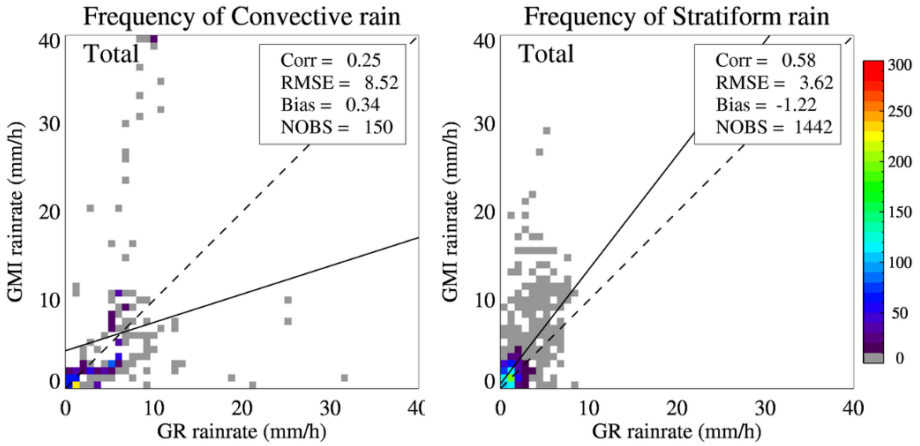


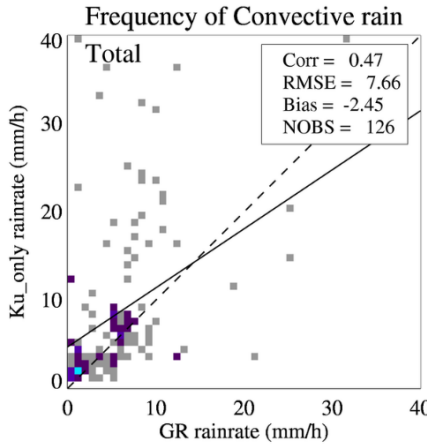
DPR_Ku

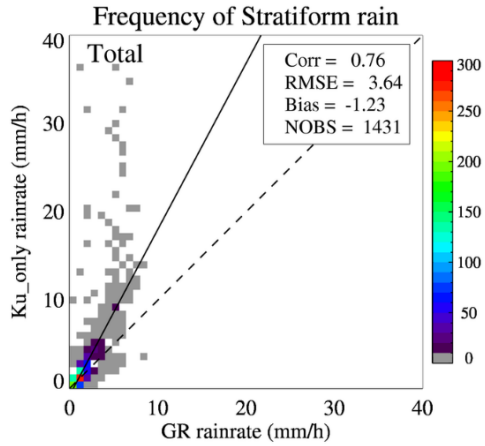




V5







9th Workshop of International Precipitation Working Group (IPWG-9)

5-9 November 2018

Seoul, South Korea

Objectives of the workshop

- **Review** the state of the art of rainfall and snowfall/high-latitude precipitation measurement techniques.
- **Discuss** the application of satellite precipitation products for research and operations.
- **Recommend** future directions to WMO/CGMS/GEWEX.

Thank you!

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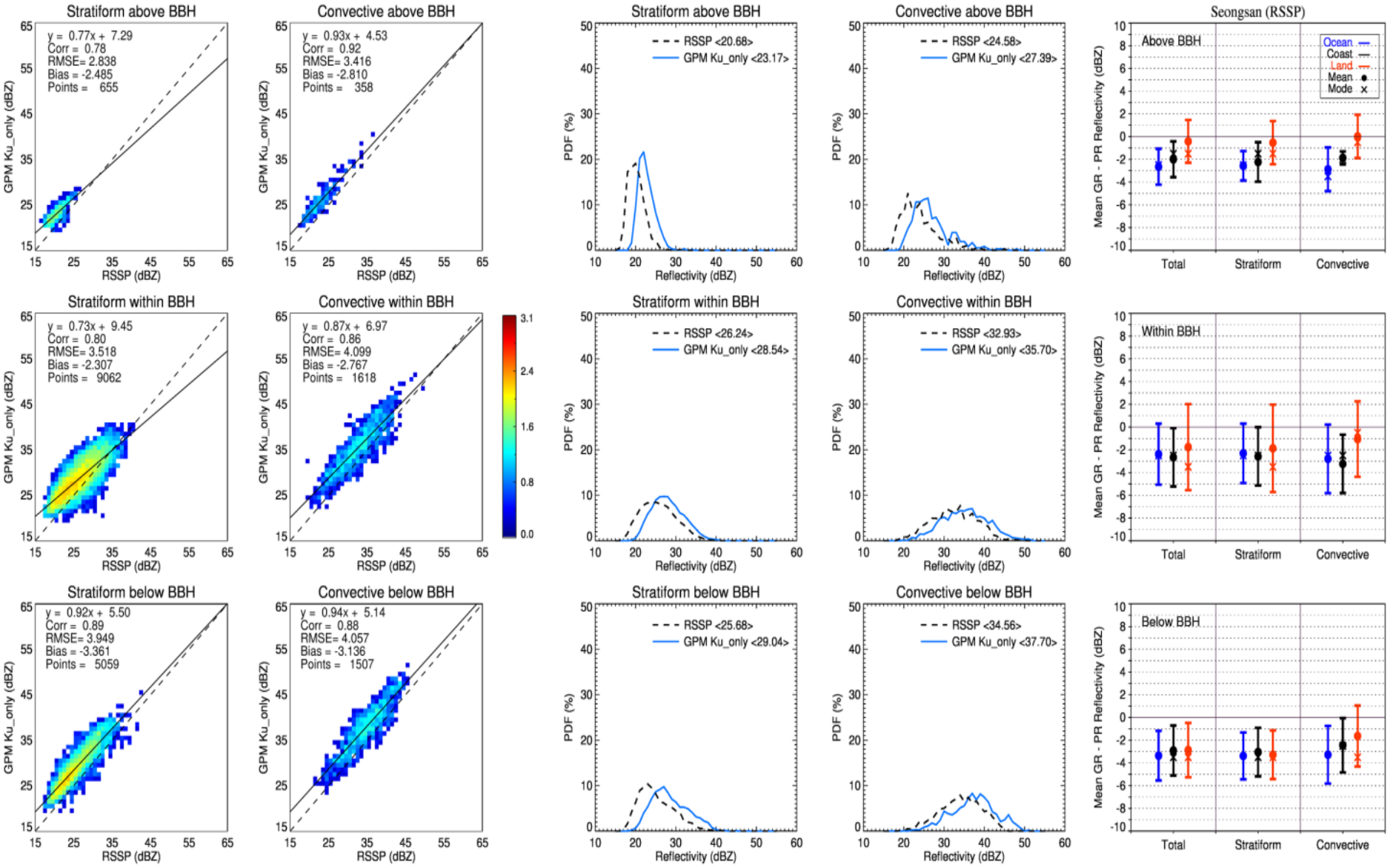
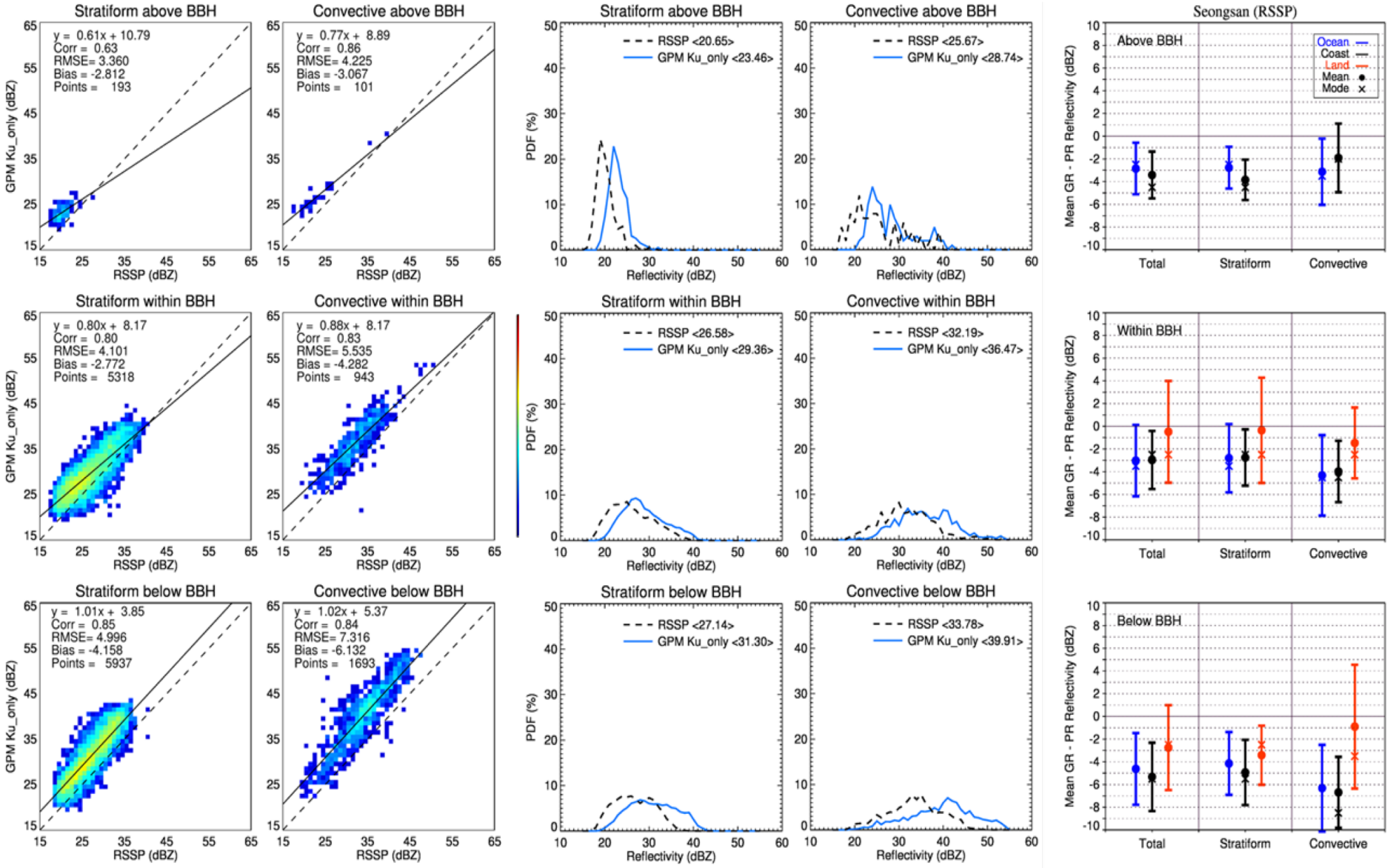
NMSC

Backup Slides

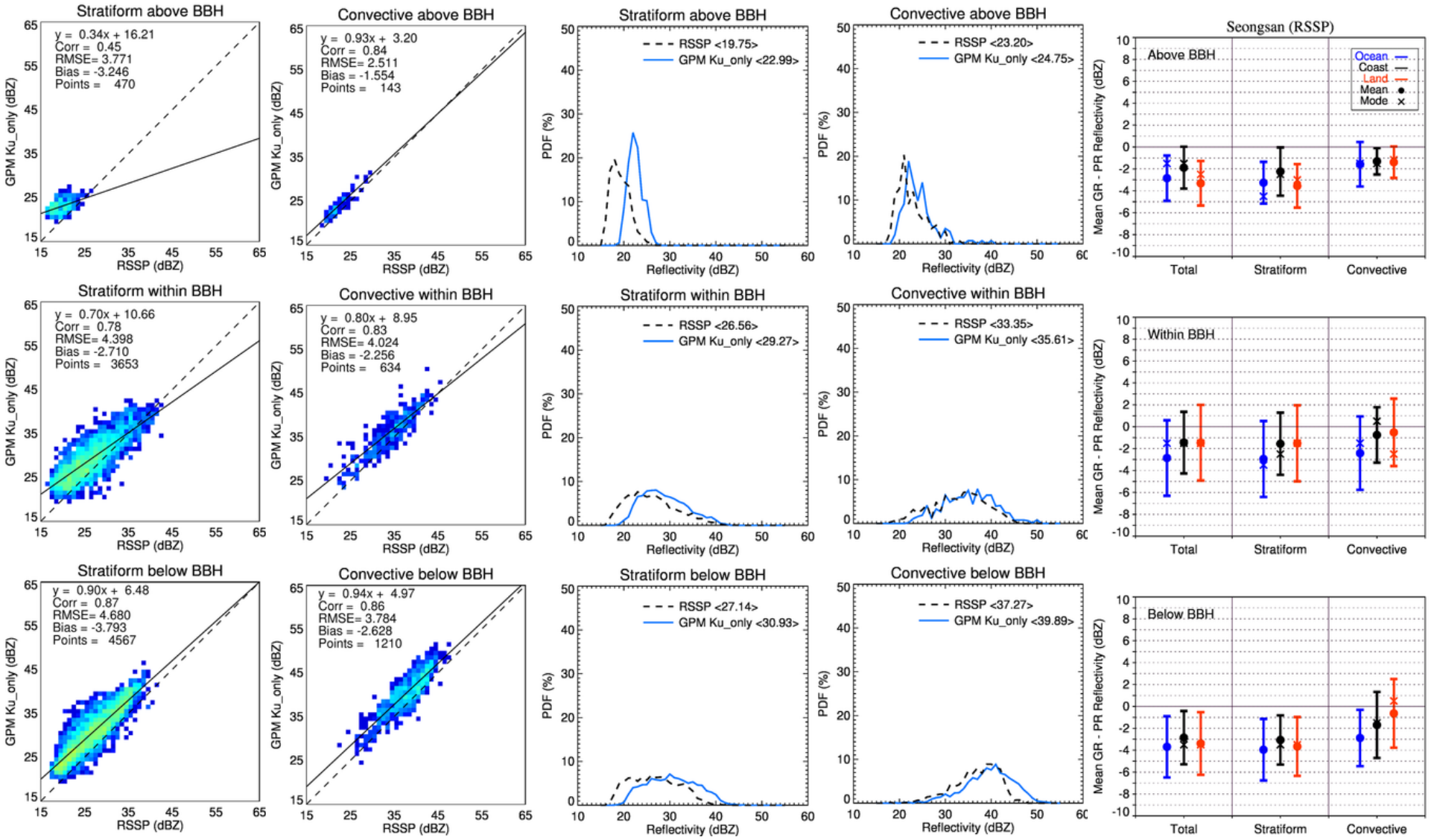
GPM Ground Validation (2015)



GPM Ground Validation (2016)



GPM Ground Validation (2017)



RAR (Radar-AWS Rainrate)

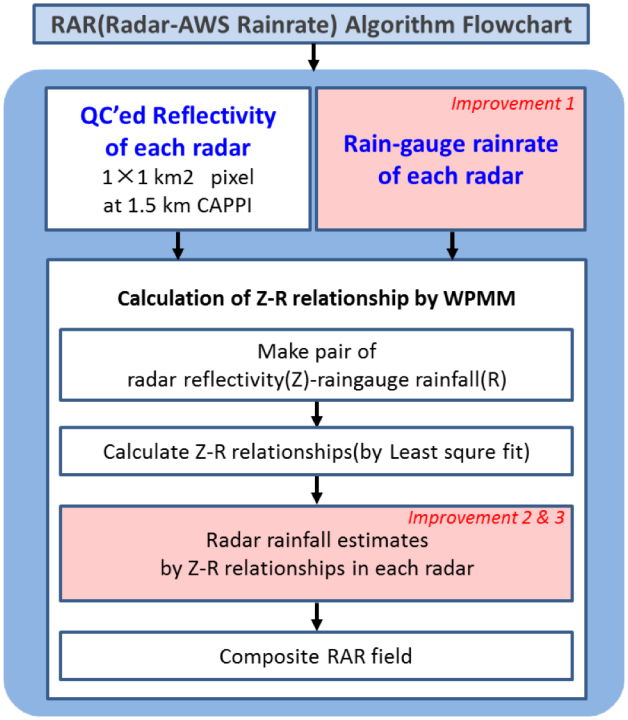
RAR in KMA

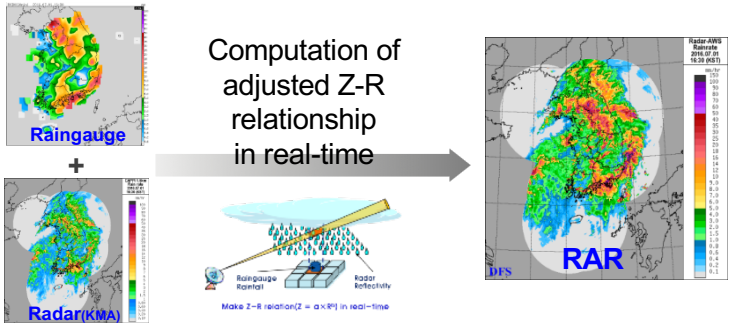
▪ Korea Meteorological Administration (KMA) has developed the adjustment techniques of radar rainfall based on rainrate from rain gauges, Radar-AWS Rainrate(RAR).

▪ RAR system provides the gauge-adjusted radar rainfall in real time by applying new coefficient ‘a’ and exponent ‘b’ in radar reflectivity(Z)-raingauge rainfall(R) relationship that based on window probability matching method every 10 minutes are derived from pairs between radar reflectivity and gauge rainrate.

	Radar	AWS	RAR
Observation Range	11 radars (All sites : S-band)	642 points in Korea Peninsula	Composition of 11 KMA radars
Spatial Resolution	1km*1km (240km range)	about 13 km	1241*1761(1 km)
Time Resolution	10 min	1 min	10 min
Unit	dBZ	mmhr-1	mmhr -1

RAR Algorithm



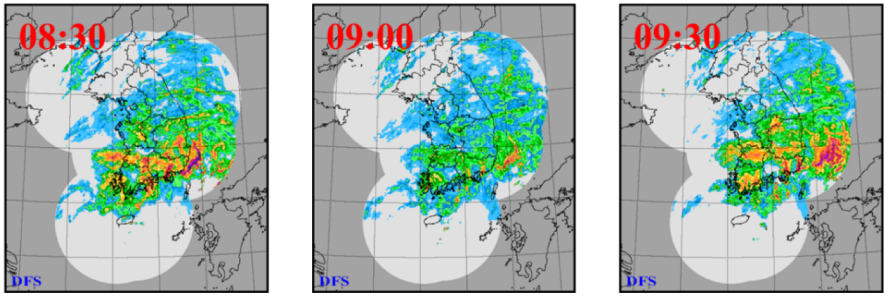


Operative RAR system

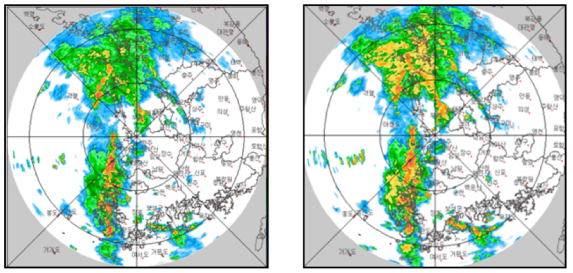
- RAR system has some the temporal variation of RAR increases at the beginning and the end stages of rainfall due to artificial errors in rainfall from TRMM-GSP algorithm, and unrealistic discontinuities.
- To improve stability due to QC-process of raingauge rainfall QC for RAR, we developed new raingauge QC program.
- For more robust RAR system, we have newly derived basic two coefficients “a” and “b” at each radar based on the long-term analysis between radar rainfall estimation and raingauge rainfall,
- Furthermore, we used bias correction method to reduce temporal discontinuity of

Sample errors

- RAR system’s artificial error due to TRMM-GSP



- Unrealistic discontinuity at the beginning of precipitation



06:10
: default relation

06:20
: real-time relation from RAR

Improvement of RAR system

In order to obtain stable RAR rainfield

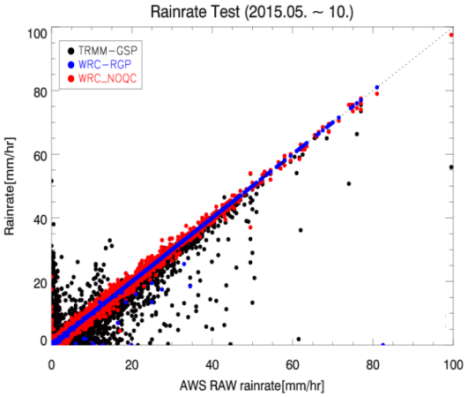
1. Improvement Rainfall QC procedure

Weather Radar Center-Rain Gauge Process (WRC-RGP, *WRC, 2016*)

This program provides a list of available raingauges within a certain radius of radar, and calculate accumulated rainfall data according to quality control method*, and time resolution selected by user.

WRC-RGP has *improved quality control performance* for raingauge rainfall, and also *reduced computation time* for QC-process.

(*Quality Control : Integrity check, Physical limit check, Checking temporal consistency, Climatological Check)

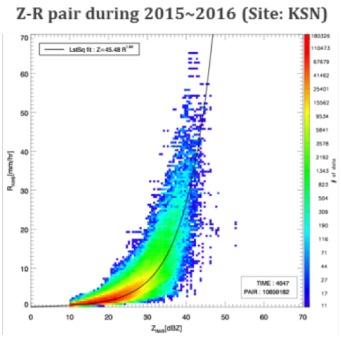


2. Applying Mean Coefficient to default relationship

The new coefficients are calculated only when the number of pairs between radar rainfall estimates and raingauge rainfall are enough. Otherwise, Marshall-Palmer (M-P) Z-R relationship is applied as a default relationship. The use of M-P relationship induces temporal discontinuity of RAR.

In order to obtain stable RAR rainfield, we've calculated the mean Z-R relationship for each radar sites.

(used period : march~october, 2015 and 2016)



3. Error Weighted correcting method to improve temporal stability

The Z-R relationship calculated in real-time is calculated independently every 10 minutes, several discontinuity exists in RAR system. We used bias correction method to reduce temporal discontinuity of rainfields

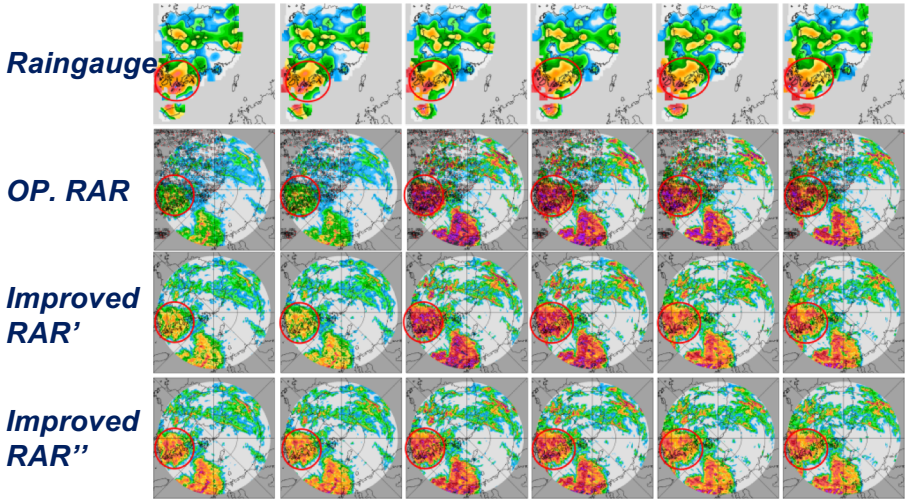
$$R_{qped} = \frac{rRMSE_2}{rRMSE_1+rRMSE_2} * R_1 + \frac{rRMSE_1}{rRMSE_1+rRMSE_2} * R_2$$

R_{qped} = Error Inverse corrected Rainrate
R_1 = QPED by Real-time Z-R relation
R_2 = QPED by Mean Z-R relation
$rRMSE_1$ = rRMSE from Real-time Z-R relation
$rRMSE_2$ = rRMSE from Mean Z-R relation

Improved RAR

Case of Improved RAR system

- *Case period: 14 APR 2017 05:40KST~06:30KST*



Applying Mean Z-R relation as default relationship and bias correction method on estimating precipitation in real-time, the amount of temporal changing impact in RAR system was relaxed.

- *Improved RAR' : applying site mean Z-R relation as default relationship*
- *Improved RAR'' : applying site mean Z-R relation as default relationship + Error Weighting Corrected*

Verification score of Improved RAR

- *Case period: 14 APR 2017 00:00KST~16:00KST*

	Operational RAR	Improved RAR'	Improved RAR''
BIAS	-0.441	**-0.322**	**-0.222**
RMSE	5.398	**4.162**	**4.074**
RMSE	0.873	**0.691**	**0.676**
CORR	0.478	**0.569**	**0.586**

The root mean square errors(RMSEs) were reduced from 87.336 to 69.111% in improved RAR', and reduced to 67.595 in improved RAR'' for this case*(improvement results has deviation by sites).*

Ground Validation Site

Site name	Site ID	Lat (°N)	Lon (°E)	Alt (m)
Jindo	JNI	34.471	126.328	499
Busan	PSN	35.115	129.001	547
Gosan	GSN	33.294	126.163	103
Seongsan	SSP	33.387	126.880	72
Baengnyeong	BRI	37.968	124.630	185
Myeonbong	MYN	36.179	128.997	1136
Gwanak	KWK	37.444	126.964	641
Gwangdeok	GDK	38.118	127.434	1061
Oseong	KSN	36.013	126.784	231
Gangneung	GNG	37.818	128.866	99
Yongin Test-bed	YIT	37.206	127.285	473
Biseul	BSL	35.694	128.535	1085
Sobaek	SBS	36.928	128.441	1408
Mohu	MHS	35.034	127.183	958
Seodae	SDS	36.225	127.543	922

KMA started to replace the radar network to S-band Dual polarization radar from 2013.
Black: Operated by KMA, Blue: Test-bed(KMA), Red: Operated by MoLIT